VARIATION OF RADIO REFRACTIVITY WITH SEASON: A CASE STUDY OF IKEJA, LAGOS STATE, NIGERIA

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Abstract- Radio refractivity is very important in the design of telecommunication systems as it affects radio communications, aerospace, GSM communication, radio links, etc. It depends on the temperature, pressure, and humidity of air. The aim of this work is to determine the change in season with radio refractivity of Ikeja, Lagos, Nigeria. The refractivity for both dry (February) and rainy (July) seasons for 2016 have been calculated using the data of temperature, pressure and relative humidity obtained from the achieve of weather online from their website. The result shows that there is a variation between radio refractivity in rainy and dry seasons. The refractivity is higher in rainy season than in dry season, mainly due to higher amount of moisture in the atmosphere (troposphere) in rainy season.

Keywords: Refractivity, Humidity, Saturated Vapour Pressure, Atmosphere

I. Introduction

The propagation of electromagnetic waves in the atmosphere (mainly the troposphere) is greatly affected by the composition of the atmosphere (Korak, 2003). These components of the atmosphere that majorly affect the propagation of electromagnetic waves in the atmosphere are temperature, relative humidity and pressure.

The refractive index of the troposphere is an important factor in predicting performance of terrestrial radio links. Refractive index variations of the atmosphere affect radio frequencies above 30MHz, although these effects become significant only at frequencies greater than about 100MHz especially in the lower atmosphere [B. G. Ayantunji et al, 2011].

The refractive index of the atmosphere is close to unity and the variation is so small, which make it difficult to work with [G. A. Agbo et al, 2013]. A more convenient variable to use when modeling the variation of refractive index in the atmosphere is the refractivity, N and is defined as:

$$N = (1-n) \times 10^6 \quad \text{--------------------- } 1$$

Where N = Radio Refractivity and n Refractive Index of air.

The refractivity itself is being affected by the tropospheric parameters (Temperature, Relative Humidity and Atmospheric Pressure) [B.A. Emmanuel and K. D Adebayo, 2013]. In this work, only these three parameters are used. Radio refractivity is very important in design of telecommunication systems. The characterization of tropospheric, N variability has great significance to radio communications, aero-space, environmental monitoring, disaster forecasting, etc. [Ali S. et al, 2012]. One significant effect of the refractivity is the fact that it creates a multipath effect as a result of the variation of the refractive index at different layers of the atmosphere, hence signal propagation tends to take different trajectories as they travel in the atmosphere; the result is that the different signals will arrive at different time to the receiver or interfere with each other at the atmosphere [B.A. Emmanuel and K..D Adebayo, 2013]. Some research works similar to this am doing have been carried out by some researchers at various parts of the country. In 2013, B.C. Isikwe *et al* carried out such a research in Makurdi, North Central Nigeria. It was discovered by them that there is a significant variation in rainy and dry season refractivity. In 2012, O.N.Okoro, and G.A. Agbo in their work "The Effect of Variation of Metrological Parameters on Tropospheric Radio Refractivity for Minna" observed a clear variation between refractivity for rainy season and dry season. In 2015, Daniel Effiong Oku et al carried out similar work in Calabar south-south Nigeria and found out that although the rare climatic conditions like that of Calabar City might distort this clear variation in some percentage but at the end, there was still a variation between dry and rainy season refractivity.

Lagos state is in south-western part of Nigeria. It has wet and dry seasons; with the rainy season from April to September, but the intense rain is from April to July, and the dry season is from October to March. It has an average temperature of 27^0c. The study location is between latitude 6.413N and 6.694N, and longitude 2.705E and 4.356E.

II. Materials and Method

i. Materials: The materials used for this work is a secondary data of temperature, pressure and relative humidity for the months of February and July 2016, obtained from the achieve of weather online on their website. This February data represents the dry season meteorological data while that of July is the rainy season data.

ii. Methods: The calculations of various parameters were done in Microsoft excel workbook using their various formulas. Graphs and tables were also prepared using the excel package. The graphs were plotted in order to allow comparison between the two refractivity; during rainy and dry seasons.

The procedure for the work is as shown below.

a. Determination of saturated vapour pressure (e_s): The saturated vapour pressure is the pressure of a liquid when it is in equilibrium with the liquid phase. It depends mainly on the temperature of the vapour or air. It is calculated using the formula;

$$e_s = 6.11\exp\left[\frac{17.26(T-273.16)}{T-35.87}\right] \text{ ---- } 2$$

Where T is the air temperature in Kelvin (K), e_s is the saturated vapour pressure in hectopascal (hpa) and exp is exponential given by a constant value of 2.718.

b. Determination of vapour pressure (e): Vapour pressure is defined as the measurement of the amount of moisture in the air. Vapour pressure is calculated using the formula;

$$e = e_s \text{ x } \frac{H}{100} \text{ --------------------- } 3$$

Where H is the relative humidity in percent, e is the vapour pressure in hectopascal (hpa) and e_s is the saturated vapour pressure calculated from (2) above.

c. Determination of Radio Refractivity (N): Radio refractivity is the physical property of the medium as determined by its index of refraction. It is the product of the refractive index less than one unit and one million. The ratio of the velocity of the radio propagation in free space to that in medium is called refractive index. Radio refractivity is calculated using the formula;

$$N = 77.7\frac{P}{T} + 3.73 \text{ x } 10^5 \frac{e}{T^2} \quad \text{-----} \ 4$$

Where P is the air pressure in (hpa), e is the vapour pressure in hectopascal (hpa) and T is the air temperature in Kelvin (K).

Table 1: Temperature, pressure and humidity data for February, 2016 obtained from the achieve of weather online.

s/n	T (^{0}c)	P (hpa)	H (%)
1	31.6	1012	53
2	31.5	1011	63
3	32.5	1010	60
4	32.8	1012	59
5	33.5	1011	45
6	33.0	1012	55
7	33.4	1014	53
8	33.6	1014	52
9	34.8	1014	40
10	35.9	1011	11
11	34.0	1011	37
12	31.8	1012	58
13	33.0	1011	54
14	33.0	1012	57

15	33.8	1010	58
16	33.0	1011	61
17	34.1	1012	59
18	34.2	1011	57
19	34.4	1009	55
20	34.1	1009	59
21	32.6	1010	63
22	34.5	1012	60
23	35.0	1010	53
24	35.3	1010	56
25	35.2	1012	50
26	33.5	1011	64
27	34.2	1010	53
28	34.5	1010	59
29	34.8	1011	53

Source: http://www.weatheronline.co.uk/weather/

Table 2: Temperature, pressure and humidity data for July, 2016 obtained from the achieve of weather online.

s/n	T(^{0}c)	P(hpa)	H(%)
1	28.5	1018	75
2	30.7	1016	65
3	29.0	1016	75
4	30.0	1017	65
5	23.9	1018	75
6	28.2	1017	80
7	29.2	1015	71
8	29.0	1016	75
9	29.9	1015	70
10	29.5	1016	75
11	29.5	1016	70
12	30.4	1015	70
13	28.0	1015	75
14	26.8	1015	80
15	29.0	1014	70
16	30.0	1012	66
17	27.0	1014	84
18	26.8	1016	85

19	27.6	1014	76
20	26.8	1015	80
21	26.9	1015	77
22	28.7	1014	76
23	27.1	1014	80
24	28.4	1013	76
25	28	1013	74
26	27.9	1014	75
27	27.3	1014	82
28	26	1014	91
29	27.2	1015	85
30	27.5	1014	81
31	26.1	1014	92

Source: http://www.weatheronline.co.uk/weather/

III. Results and discussions

Table 3: Radio refractivity for the month of February 2016

$T(^0c)$	T(K)	P (hpa)	H(%)	N (n-unit)
31.6	304.6	1012	53	356.396
31.5	304.5	1011	63	374.239
32.5	305.5	1010	60	373.281
32.8	305.8	1012	59	373.316
33.5	306.5	1011	45	347.965
33	306.0	1012	55	366.333
33.4	306.4	1014	53	364.629
33.6	306.6	1014	52	363.478
34.8	307.8	1014	40	342.812
35.9	308.9	1011	11	279.268
34	307.0	1011	37	333.080
31.8	304.8	1012	58	366.613
33	306.0	1011	54	364.085
33	306.0	1012	57	370.321
33.8	306.8	1010	58	375.807
33	306.0	1011	61	378.046
34.1	307.1	1012	59	379.958

34.2	307.2	1011	57	376.002
34.4	307.4	1009	55	372.247
34.1	307.1	1009	59	379.200
32.6	305.6	1010	63	379.645
34.5	307.5	1012	60	384.236
35	308.0	1010	53	371.102
35.3	308.3	1010	56	379.272
35.2	308.2	1012	50	365.917
33.5	306.5	1011	64	386.809
34.2	307.2	1010	53	367.285
34.5	307.5	1010	59	381.584
34.8	307.8	1011	53	370.386

Table 4: Radio refractivity for the month of July 2016

$T(^0c)$	T(K)	P(hpa)	H(%)	N (n-unit)
28.5	301.5	1018	75	381.196
30.7	303.7	1016	65	375.148
29	302	1016	75	383.345
30	303	1017	65	371.979
23.9	296.9	1018	75	359.737
28.2	301.2	1017	80	387.197
29.2	302.2	1015	71	377.584
29	302	1016	75	383.345
29.9	302.9	1015	70	379.523
29.5	302.5	1016	75	386.077
29.5	302.5	1016	70	377.714
30.4	303.4	1015	70	382.164
28	301	1015	75	377.827
26.8	299.8	1015	80	379.142
29	302	1014	70	374.679
30	303	1012	66	372.415
27	300	1014	84	385.809
26.8	299.8	1016	85	386.677
27.6	300.6	1014	76	377.057
26.8	299.8	1015	80	379.142

26.9	299.9	1015	77	375.274
28.7	301.7	1014	76	382.829
27.1	300.1	1014	80	380.453
28.4	301.4	1013	76	380.965
28	301	1013	74	375.763
27.9	300.9	1014	75	377.058
27.3	300.3	1014	82	384.501
26.0	299	1014	91	390.168

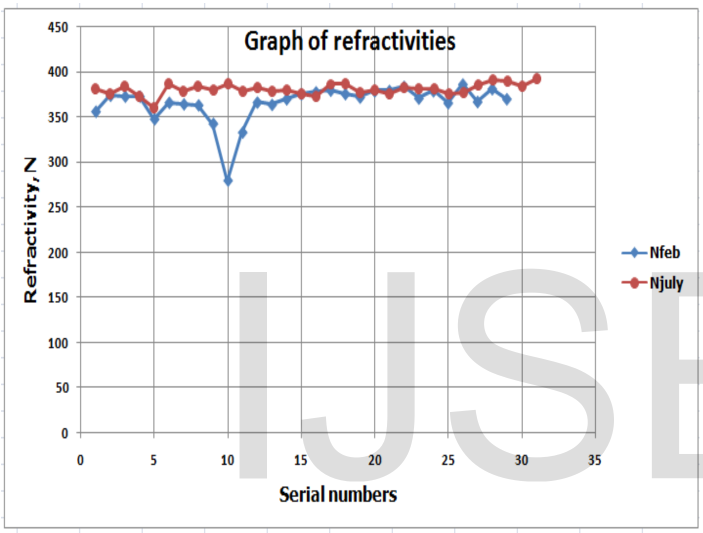

Fig. 1: Comparison between the February and July Radio Refractivity

Nfeb = Radio refractivity for the month of February and Njuly = Radio refractivity for the month of July.

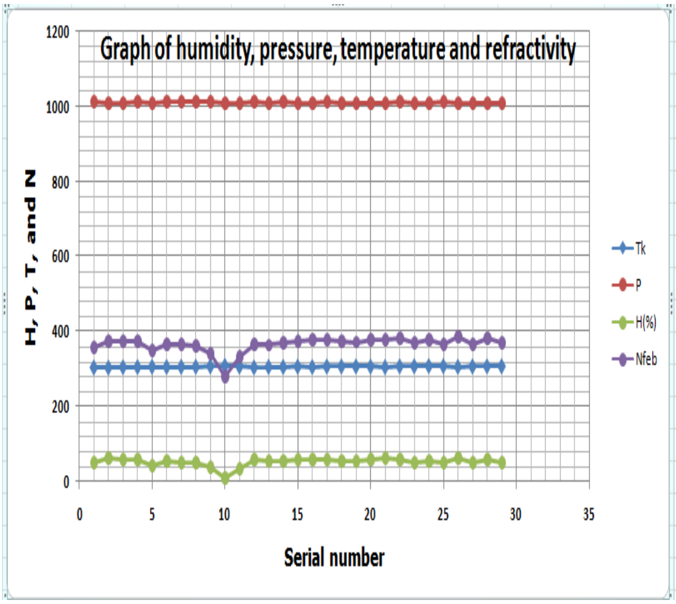

Fig. 2: Graph of humidity, pressure, temperature and refractivity for February 2016

Tk = Tempetraure, P = pressure, H (%) = Relative humidity and Nfeb = Radio refractivity for the month of February.

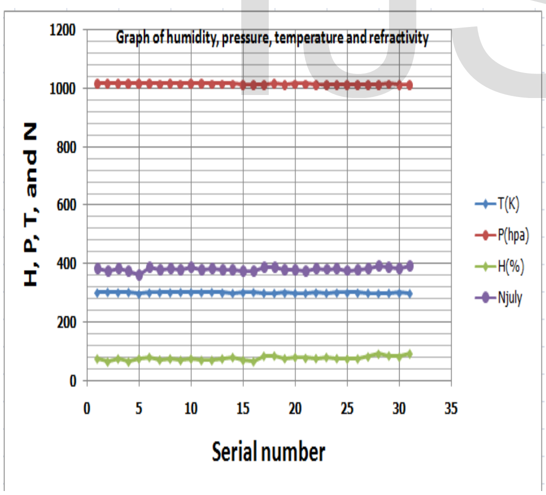

Fig. 3: Graph of humidity, pressure, temperature and refractivity for July 2016

Fig. 2: Graph of humidity, pressure, temperature and refractivity for February 2016

Tk = Tempetraure, P = pressure, H (%) = Relative humidity and Njuly = Radio refractivity for the month of July.

The variation of radio refractivity with season has been determined using the meteorological data of the two seasons in a year in Nigeria, which are rainy and dry seasons. The rainy season spans from April to September while dry season spans between October to march. The refractivity for rainy season was determined using the data for the month of July and that of the dry season was determined using the data for the month of February. The two sets of data were obtained from the achieve of weather online on their website - http://www.weatheronline.co.uk/weather/maps/. The result shows that radio refractivity is higher in rainy season (July) than in dry season (February) as shown in fig. 1. In dry season, the maximum and minimum refractivity are 386.81 N-units and 279.27 N-units, while that for rainy season are 392.15 N-units and 359.73 N-units respectively. Furthermore, the average refractivity for rainy and dry seasons are 380.31 N-units and 366.32 N-units in that order [Tables 3 and 4]. This might be as a result of high moisture content in the atmosphere in rainy season than in dry season. This is in accordance with figures 2 and 3 in which the refractivity for both February and July responded to change in relative humidity (or amount of moisture in the air) as compared to its response to other parameters. Although at a point in February (dry season), the radio refractivity was higher than that of July (rainy season), it was due to the sudden fluctuations in the humidity from 50% to 64% and then back to 53%.

IV. Conclusion

With the refractivity for two different seasons (rainy and dry) determined, and the result shown with the maximum refractivity of 392.15 N-units for rainy season and are 386.81 N-units for dry season, it can be conclusively stated that radio refractivity varies with seasons (rainy and dry), and that it is high in rainy season and less in dry season. This is a confirmation of the works carried out by B.C. Isikwe et al, 2013 in Makurdi, O.N.Okoro, and G.A. Agbo, 2012 and G.A. Agbo, O.N. Okoro and A.O. Amechi, 2013 in Abuja in particlular,all in North central Nigeria.

V. Recommendation

Although, the above result has clearly shown that there is variation in radio refractivity of Lagos with seasons, the data obtained from achieve of weather online on their website which was used for this work was for one year, i.e. 2016. The data for the same moths (February and July) for the last five years should be used for further works.

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VI. References

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